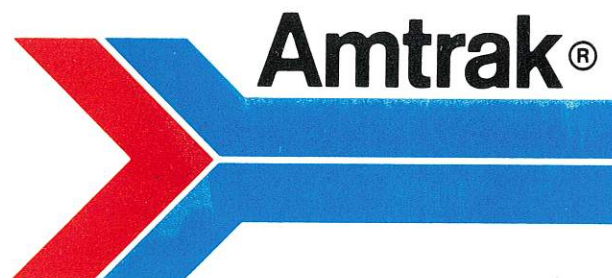


# **NATIONAL RAILROAD PASSENGER CORPORATION**



# **THE ART OF SCHEDULE ANALYSIS**

**National Railroad Passenger Corporation  
Contract Management  
March 28, 1996**

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## **The Art of Schedule Analysis**

### **Introduction and Acknowledgments**

The ability to properly analyze a schedule is truly an art. The following paper is intended to be a guide for people who are qualifying on how to properly evaluate schedules. It is based on experience gained by a small cadre of experienced riders over a 20-year period and represents hundreds of thousands of miles and thousands of hours of making field checks. Several years ago we developed a training course on schedule evaluation that has been refined over a period of time. This paper is designed as an aid to personnel who are about to receive that instruction.

We wish to acknowledge the assistance of Arthur Prentiss and Al Walton of my staff who carefully critiqued the draft. We also wish to acknowledge the assistance of Chris Dort and Rande Jones, locomotive engineers for Amtrak who reviewed the final draft. We also appreciated editorial assistance from R. H. Young, Assistant Vice President Passenger Services, CSX; Howard Godwin, Director of Passenger Operations, CSX; and Ray Shields, Manager of Passenger Operations, CSX; all of whom are certified locomotive engineers, as well as Cliff Russ, Director of Passenger Services for CSX. Their input was most valuable.

Our final comment to all who are about to board the engine, whether in engine service or to perform a schedule evaluation, is "Have a safe trip."

James L. Larson  
Washington, DC  
March 28, 1996

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**THE ART OF  
SCHEDULE ANALYSIS**

## **Background**

When Amtrak assumed responsibility for the operation of intercity passenger trains in 1971, it inherited the existing schedules of the freight railroads. Some of these schedules were poor, some were good, and some needed restringing. From 1971 until 1974, there was no strong working relationship between Amtrak and the railroads that addressed on-time performance and schedules. As a result, performance deteriorated. In 1974, the first incentive agreements were negotiated with the carriers but little was done to rationalize or improve schedules. Many lessons were learned from those First Amendment Agreements and in 1976, with the advent of the Second Amendment Agreements, refinement and negotiation of schedules became an integral part of the operating agreement and of financial arrangements between Amtrak and the freight railroads.

As a result, the 1976 contract negotiations resulted in the development of the schedule analysis program which, with moderate refinements, is in use today. In 1976, incentive payment potential was tied to the quality of the schedule and appropriate speeds. Since the Third Amendment Agreements of 1980, essentially all long-distance trains have been tied to intermediate point on-time performance. This is measured from A to B, A to C and A to D, etc., with A being the initial point on the railroad. This methodology does not permit a carrier to have a poor operation from A to B and get a fresh start from B to C or from C to D.

The Third Amendment Agreements also contain penalty provisions for poor performance. This is required by the Rail Passenger Service Act. Both the intermediate performance and penalty provisions are critical components of the post-1996 agreements as well.

Performance payments are measured on an individual train basis each month. Incentives are paid if the train operates between 80% and 100% on time. Performance between 70% and 80% does not earn incentives, and performance below 70% incurs penalties at the same rate as incentives are paid above 80%. The penalties are against incentives earned during the previous twelve months.

Incentives are not an insignificant item. The maximum potential for the industry is approximately \$55.5 million per annum. During the five years FY '91 to FY '95 Amtrak paid an average of \$22.5 million per annum. This is not an insignificant amount of money. If Amtrak were a freight shipper and the industry transportation ratio was 80%, it would take approximately \$110 million in gross revenue to produce the same results for the freight railroads. Amtrak encourages the industry to seek incentive payments. The down side of the numbers quoted above is that the industry has only earned approximately 40% of its incentive potential over the past six years. Reasonable diligence in expediting passenger trains should earn 50% of the potential (some carriers earn 80% or more of their potential), which means that approximately \$11 to 22 million is left on the table each year. A critical element of the incentive program is the quality of the schedules.

One final comment on schedule performance and incentives. An order of magnitude on incentive potential on an 1800-mile train would be \$5,400 per trip or \$162,000 in a 30-day month. At 90% on time, it would earn \$81,000 in that month. However, some railroads look at the potential from a different perspective. The first 24 trains must be operated on time before they are "in the money," then each of the remaining 6 trains is worth \$27,000. Their perception that each train lost is money left on the table is absolutely correct.

Why are the incentives such a significant item when it comes to preparing schedules? The answer is, that well strung schedules are critical to on-time performance and therefore play a critical roll in generating incentives.

In our paper on scheduling, we pointed out that with a schedule that has too much time the train will run late, just as a train without sufficient time will run late. The train with too much time is likely to take a beating from the dispatcher because of the excess time and it will frequently run late just as the train with insufficient time.

Remember, there are three basic components to schedule construction. They are:

- 1) Pure Running Time.
- 2) Dwell Time.
- 3) Recovery Time



What might be considered a fourth component is passenger train meets, but that is actually extra time built into the schedule to compensate for the meets.

Pure Running Time is the amount of time required to go from one station to the next, without delay, and is based upon a predetermined power-to-weight ratio.

Dwell Time is the amount of time required at a station to perform station work. In addition to passenger handling it may also include time for mail, baggage or express, crew change, switching, inspection or servicing.

Recovery Time is the amount of time added to the above components to compensate for delays encountered en route. It is generally in the range of 6% to 8% added to the above times.

Remember, when the amount of delay exceeds the available recovery time, the train is late.

The task in analyzing a schedule is to factor out all delays en route and to divide the schedule into the three basic components. The task is not easy but once an individual is familiar with the proper procedure it can be accomplished with amazing accuracy. Frequently, Pure Running Time is calculated over long segments by different

riders with only a fraction of a minute variance in their respective reports between stations or over the entire route.

### **Objective**

Welcome to the world of schedule evaluation. Once you have completed the classroom instruction and field training with this program, you should be able to divide a schedule into its three basic components:

- Pure Running Time
- Dwell Time
- Recovery Time

In addition, you should be able to quantify delays by causal factors and determine the percentage of recovery time. A final check is determining how well the train was handled consistent with the rules and applicable speed restrictions. Remember, the purpose of this program is to effectively analyze schedules, not to perform crew evaluations.

### **Preparation**

Life all night on an engine can be a grueling experience, especially riding the jump seat on an F40. There is much you can do prior to the trip to make life considerably easier during the evaluation; however, there is nothing you can do to make life easier on the jump seat except stand up.

On longer trips where two or three team members will participate, the segments each person will check must be determined in advance. At locations where riders are going to change, it is the responsibility of the relieving rider to record the arrival and departure times at the change-off point; however, it is also good practice for the arriving rider to do the same. It is also important for the riders to synchronize their watches before the trip.

If the check is to address operating problems or freight train interference it is best for the dispatcher to be unaware of the riding program. However, there are times when a joint riding program is made to evaluate schedules, it is advisable to inform the dispatcher of the test in order to obtain data with a minimum of delays.

A major portion of the task is quantifying delays; therefore, it is necessary to know the maximum authorized speeds and station locations. This comes from the operating timetable; however, operating timetables of today are not easy to carry, may be only slightly smaller than a telephone book, and frequently require the reader to hop from one page to another as districts or subdivisions change. Therefore, the first tools you need are a scissors and tape to make yourself a customized timetable that follows the route of the train. A sample of the cut and paste (tape) timetable is shown in Exhibit 1. This is an important part of the evaluation.

In addition, it is a good practice to review the Special Instructions and the track charts at the office before you go on the road, especially when you are not familiar with the territory to be evaluated. However, it is not recommended that you carry this information because it is normally too bulky and heavy to carry conveniently. In reviewing the track charts or timetable, watch for equations in Mile Posts.

In addition, you should prepare in advance the Summary Sheet (Trip Report) for the train showing the pertinent information for that train including station stops and checkpoints and current schedule. The rest of the information will be written on the form as the trip progresses. This form is shown as Exhibit 2.

The consist book should be reviewed to determine the normal consist of the train. Sometimes it is necessary to add one or more cars to obtain the proper power to weight ratio for the test, or to hold a deadhead car for movement at a later date in order to maintain the integrity of the test. In like manner the power consist should also match the desired test. This should not be left solely to chance.

## EXHIBIT 1

**10.0 NAHUNTA SUBDIVISION-NH**

| MP/<br>Ctr Pt       | ↓ SOUTH ↑      | STATIONS                               | SDG<br>CAP (Ft) |
|---------------------|----------------|----------------------------------------|-----------------|
| A639.4<br>1441-1442 | NS<br>MONCREEF | Jacksonville<br>(Pasgr Station)<br>3.1 |                 |
| A642.5              | SANFORD SD     | Beaver St.                             |                 |

**50.0 WILDWOOD SUBDIVISION-BL**

| MP/<br>Ctr Pt                         | ↓ SOUTH ↑              | STATIONS                      | SDG<br>CAP (Ft) |
|---------------------------------------|------------------------|-------------------------------|-----------------|
| SP635.1                               | NAHUNTA SD             | Beaver St.                    |                 |
| SP635.2                               | WEST JAX               | 3.5<br>Seminole<br>Connection |                 |
| SP639.0<br>1506                       | DUVAL                  | 3.5<br>Carnegie               | 4003            |
| SP643.9<br>1508-1509                  |                        | 4.9<br>Whitehouse             | 7010            |
| SP652.6<br>1513                       |                        | 6.7<br>East Pass              | 7327            |
| S653.3                                | BALDWIN YD<br>JAX TERM | 6.7<br>Baldwin Yard           |                 |
| S655.8<br>1514                        | No. 1                  | 2.5<br>Baldwin                |                 |
| S678.4<br>1516                        | No. 2                  | 22.6<br>Starke                |                 |
| S680.1<br>1518                        | BOOKER SD              | 1.7<br>Newman                 |                 |
| S685.1<br>1519-1520                   |                        | 5.0<br>Hampton                |                 |
| S690.0<br>1522-1523                   |                        | 4.9<br>Waldo                  | 10,290          |
| S696.6<br>1524-1525                   |                        | 6.6<br>Orange Height          | 10,273          |
| S703.3<br>1526-1527                   | EDGAR SD               | 6.7<br>Hawthorne              | 10,214          |
| S712.3<br>1528-1529                   |                        | 9.0<br>Lochloosa              | 10,228          |
| S719.8<br>1530-1531                   |                        | 7.5<br>Sparr                  | 11,708          |
| S735.3<br>1532-3-4-5                  | FW RT                  | 15.5<br>Ocala                 | S10,119         |
| S743.5<br>1536-1537                   |                        | 8.2<br>Santos                 | N3869           |
| S752.0<br>1538-1539                   |                        | 8.5<br>Summerfield            | 10,152          |
| S759.9<br>1540                        |                        | 7.4<br>N Wildwood             |                 |
| S761.2<br>1542                        |                        | 1.8<br>Wildwood               |                 |
| 126.1 MILES<br>BEAVER ST. TO WILDWOOD |                        |                               |                 |

**13.1 MAXIMUM AUTHORIZED SPEED**

Table 4. Maximum Authorized Speed

| Between Location/Mile Post | MPH |
|----------------------------|-----|
| A506.0, and A638.7         | 79  |
| A638.7 and A642.5          | 40  |

**53.1 MAXIMUM AUTHORIZED SPEED**

Table 38. Maximum Authorized Speed

| Between Location/Mile Post | MPH |
|----------------------------|-----|
| Jacksonville and SP635.2   | 40  |
| SP635.2 and Wildwood       | 79  |

**53.2 SPEED RESTRICTIONS**

Bold MPH denotes city ordinance.

Table 39. Speed Restrictions

| Between Location/Mile Post                      | Pasgr.<br>MPH | Other<br>MPH |
|-------------------------------------------------|---------------|--------------|
| SP635.0 (A642.5) and<br>SP635.3 (Honeymoon Wye) | 15            | 10           |
| SP635.3 and SP635.5                             | 30            | 30           |
| SP635.5 and SP639.1                             | —             | 45           |
| Beaver Street Tower-Diverging Moves             | 15            | 15           |
| SP652.4 and SP653.0                             | 30            | 30           |
| S653.0 and S653.9                               | 70            | —            |
| S670.8 and S672.1                               | —             | 60           |
| S678.4 and S679.0                               | 45            | 45           |
| S690.0 and S690.2                               | 45            | 45           |
| S690.2 and S690.6                               | 45            | 45           |
| S704.4 and S705.4                               | 45            | 45           |
| S709.5 and S710.7                               | 75            | —            |
| S731.1 and S731.7                               | 60            | 60           |
| S731.7 and S733.9                               | 70            | 60           |
| S733.9 and S734.7                               | 60            | 60           |
| S734.7 and S736.2                               | 30            | 30           |
| S736.2 and S740.8                               | 55            | 55           |
| S746.7 and S747.5                               | 40            | 40           |
| S747.5 and S750.8                               | 70            | —            |
| S760.2 and S760.6                               | 65            | 60           |
| S760.6 and S761.2                               | 20            | 20           |

Table 39. Speed Restrictions

| Between Location/Mile Post                                                                                       | Pasgr.<br>MPH | Other<br>MPH |
|------------------------------------------------------------------------------------------------------------------|---------------|--------------|
| Signaled Sidings at Whitehouse,<br>Baldwin, Orange Height, Hawthorne,<br>Sparr, Ocala (Southward Siding), Santos | 25            | 25           |

## EXAMPLE OF SUMMARY SHEET

EXHIBIT 2

Date 2-5-96

## TRIP REPORT

Rider JLLTrain 91 Engs. 401-263Consist 9 cars

| SCHEDULE | ACTUAL | STATION          | SCHED. TIME | ELAPSED TIME | DWELL | DELAYS | PURE-RUNNING TIME | RECOV. TIME |
|----------|--------|------------------|-------------|--------------|-------|--------|-------------------|-------------|
| 635 AM   |        | Jacksonville     |             |              |       |        |                   |             |
| 734 AM   |        | Waldo            | 59          |              |       |        |                   |             |
| 819 AM   |        | Ocala            | 45          |              |       |        |                   |             |
| 848 AM   |        | Wildwood         | 29          |              |       |        |                   |             |
| 926 AM   |        | Dade City        | 38          |              |       |        |                   |             |
| 1016 AM  |        | Winter Haven     | 50          |              |       |        |                   |             |
| 1057 AM  |        | Sebring          | 41          |              |       |        |                   |             |
| 1132 AM  |        | Okeechobee       | 35          |              |       |        |                   |             |
| 1235 PM  |        | West Palm Beach  | 63          |              |       |        |                   |             |
| 1256 PM  |        | Delray Beach     | 21          |              |       |        |                   |             |
| 115 PM   |        | Deer Field Beach | 19          |              |       |        |                   |             |
| 133 PM   |        | ft. Lauderdale   | 18          |              |       |        |                   |             |
|          |        |                  |             |              |       |        |                   |             |
|          |        |                  |             |              |       |        |                   |             |

## **Equipment**

Each person can develop their own equipment kit to suit their own needs; however, certain basic items are essential. First, you need proper footwear, ear plugs, and safety glasses, and always remember that compliance with safety rules and operating rules is essential. For recording purposes you need a pad of paper, pens (at least two colors), a clipboard or something to hold the pad firm, a small flashlight, extra batteries, a calculator, and a reliable watch because you will need to record times to the nearest second. A digital watch makes life much easier, especially while bouncing on the engine in the middle of the night trying to discern whether the minute hand is at 32 or 33. A copy of a previous riding report can also be a valuable aid but is not essential. While a stop watch is recommended by some, you can generally rely on the engine crew to have one or to check the accuracy of the speedometer once you are on the road. You can only carry so much equipment conveniently. Finally, don't forget your headend permit. Crews should ask for it; however, you should always volunteer it.

Now, with this preparation, we are ready to board the engine.

## **Boarding the Engine**

Boarding the engine is a ritual. Remember, you are invading the sanctum sanctorum of the engine crew. They may eye you with suspicion and wonder "what that (expletive deleted) wants." Introduce yourself and advise the crew that you are doing a schedule check from A to Z and offer them your headend permit. It is important to break the ice at this point so they are comfortable with your presence and understand you are

not there to check their performance. They will ask you a standard line of test questions such as:

1. What do you do for the railroad?
2. How long have you worked for the railroad?
3. What railroad did you work for before you came to Amtrak?
4. Have you ever been on an engine before?
5. Have you ever been over this line before?

The last question is a good one because, if the answer is no, they are most likely prepared to give you an operational guided tour over their railroad.

There are also some key points or questions you want to discuss with them such as:

1. How is the schedule over your segment? This is a good ice breaker as it indicates you are interested in their opinion and you can usually get some good information from them. Some engineers can give you precise information on the operation; others will give you important tips or have recommendations that can improve the schedules. Their recommendations are important.



2. Ask them not to advise the dispatcher that you are there because you want to see what they have to put up with on a normal day. Crews generally appreciate and honor this.<sup>1</sup>
3. Request of them that since this a schedule check, they should run as close to the speed limit as they can. This always results in the same answer, "We always do." But in actuality they do not always do that. Your presence may cause them to run 3 mph under the speed limit or perhaps they do this on a regular basis. In any event this destroys the integrity of the schedule check and your efforts and loss of sleep may be for naught. In like manner, speeding destroys the integrity of the check; however, this is seldom, if ever, a problem today.
4. Advise them that if they have to kill time on the road to advise you in advance of slowing down so you can capture the delay.
5. Finally, and most important of all, ask them to review with you all of their restrictions, bulletins and track warrants for work orders, slow orders and other restrictions. These must be recorded in the upper right-hand corner of your work sheet as you will have to watch for them and capture the delay as the schedule check progresses.

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<sup>1</sup> As previously mentioned, there may be occasions, such as a joint riding program, where it is desirable for the dispatcher to be aware of the test.

All of the above should be completed before you are on the move, if possible.

Once you are on the move there are two key rules, as follows:

1. Conversation -- Avoid idle conversation to the maximum extent possible. Don't volunteer any such conversation.

2. Call Signals -- Calling signals doesn't require much effort but it is a good sign to the crew that you are a professional. Most important, it is required by the rules.

Remember, it is perfectly proper while en route to ask questions pertaining to the operation such as: "What is your normal speed here?" or "Do you normally get an Approach Medium signal at this location?" or "Do we have authority to go through Smith's work limits?"

Questions such as "Are you going moose hunting again this year?" or "Do you think the Cubs are going to make it this time?" are superfluous and distracting and are not proper conversations on the headend.

Remember, when engine crews change, thank them for their hospitality and for the information provided. Also remember to brief the relieving crew on items 1 to 5 above.

### **What Are the En Route Tasks?**

The key is to record the operation of the train so you can properly quantify delays or so you can reconstruct the trip at some later date. Depending upon the circumstances, you could even be called to testify from your notes at some future date before a panel or even in court. It is therefore necessary to develop your own style of shorthand. The key is having sufficient information to reconstruct the trip. Writing down the time and speed at every mile post is overkill and is not really necessary; however, more frequent records at first may help you in quantifying delays.

If we are measuring the running time between stations, why is it necessary to write down intermediate mile post times? The answer is that you don't unless the train is going to be delayed, which you cannot always anticipate. However, once a delay occurs you need that time and location to reconstruct the amount of delay.

So what kind of information do I record? There are a number of key elements to record; you can keep as busy as time permits. You must record the arrival and departure times at all stations and key checkpoints. For example, 21st Street Tower in Chicago is a junction between Amtrak and Conrail and the Illinois Central; therefore, the time at that point must always be recorded. Mile Posts are a good point because they represent a finite location that you can always relate to; however, you must always be on guard for equations such as MP 795 follows MP 793 (there is no 794) or where line changes have been made, for example, after MP 793 the next MP is 825. The times at

sidings may be checked at the siding switches or at the station sign. It is a good idea to show all trains met or passed and their locations. On congested lines noting the status of each siding, whether clear or occupied, is a good idea, and all signals that are displaying other than their "normal" indication should be recorded. In addition, where a speedometer is readily available, it is a good idea to record the speed at a mile post when accelerating or when the maximum speed cannot be maintained.

What if I lose my location, how can I tell where I am? Obviously the Mile Post is the best method; however, some Mile Posts are missing, obscured, or may be hard to find. Some carriers, such as the Union Pacific, mark 1/4, 1/2 and 3/4 miles with one, two or three rings around the C&S poles. Beware of signal numbers because the last number is normally not related to tenths of a mile. For example, Signal 962-1 is somewhere between MP 962 and 963 but the 1 may indicate it is a Westward signal, or that it governs Track 1, not that it is located at MP 962.1. Do not try to use signal numbers to measure distances. Numbered control points are generally in relation to mile posts but do not relate to specific mile posts unless the location is identified in the timetable. Finally, if you don't know your precise location, ask the engineer, who will know.

A sample of a worksheet is shown as Exhibit 3. As delays are quantified on the worksheet, they should be circled with a pen of a different color or highlighted with a marking pen, so they can be easily identified. The worksheet becomes the underlying

document for the Summary Sheet (Trip Report). You will be surprised at the amount of information that can be recorded by being diligent and observant in making your notes.

Remember, engineers are professionals and generally take pride in their work. Their input can be valuable. Their estimation of delay is not always accurate and is generally not precise enough for this study, but it can be used as a reality check against your more precise calculations.

# EXAMPLE OF WORK SHEET

EXHIBIT 3

No. 91 2-5-96 2 F40s 9 cars JLL Weather Clear, C14 (below freezing)  
Engs 401, 263

## RESTRICTIONS

No. 81 Arrd Jax 7:18:38 Lft 7:49:55

No. 91 doubled to train 8:00:05

Wait to complete working mail

Air test 8:10:44 Als. 8:12:57

(blue flag down 8:16:44)

Lft Jax 8:17:50

Beaver St. 8:24:45

W. End Honeymoon Wy 8:25:47

Stop { 8:26:38 DBHB Indication  
8:30:43 Head Coach

mp 638 8:34:28

mp 641 8:36:43

mp 650 8:43:28

Baldwin 8:45:34

mp 660 8:52:44 - Mt. Local 2317N

mp 670 8:59:47

mp 676 9:04:17 - Approach Signal

mp 679 9:07:28

mp 680 9:09:35-43 End of DT

Stop + Proceed at Rest. Signal

mp 681 9:13:23

mp 682 9:17:09

Clear Sig. 682.5 9:19:19

mp 690

Waldo s { 9:28:32  
9:32:20

mp 692 9:34:52

mp 695 9:37:14

mp 700 9:41:16

stop { 9:44:40 Stop for Inspn.  
9:50:44 HOD did not report

mp 704 9:51:29

mp 713 9:59:21

mp 715 10:00:50

mp 720 10:08:59

mp 682.4-690.7 0900 h. Work order

mp 682.4-682.5 30 mph

mp 683.9-684.1 30 mph

mp 688.5-686.6 30 mph

mp 695.5-696.6 60 mph

mp 704.5-718.7 0830 h. Work Order

mp 784.6-784.8 25 mph

mp 718.1-718.5 25 mph

mp 716.3-717.3 25 mph

mp 1003.4-10035 0900-1100 h Work Order

mp 1004.8-1007.7 Main Trk 0700 Work Order

mp 1012.4-1013.5 0700 h. Work Order

mp 721 10:09:51

Ocala s { 10:22:23  
10:27:05

mp 743 10:36:17

mp 750 10:42:50

mp 760 10:50:27

Willowood s { 10:53:48  
10:54:06 - Mt 7088N

mp 765 10:59:21

mp 770 11:04:20

mp 771 11:05:13

Bushnell fl. - App. Med Sig N. end of  
sdg - then Approach

Extra SPB490 Stop at Sig S. end of  
Clearing sdg. Cleared 11:08:52

mp 777 11:12:10

mp 780 11:14:43

mp 788 11:23:02

mp 790 11:24:57

mp 825 11:27:47

mp 830 11:32:27

Dade City s { 11:33:10  
11:33:34

N. end Stokes Y125 Not in Clear X4310



Remember, you started the Summary Sheet (Trip Report) before you left. the Summary Sheet is where you break the schedule into the basic components. This is an important task since the Summary Sheet is the final document that goes into the files and will be used for future schedule evaluation. The Trip Report should be completed (at least for your segment) if possible, while you are en route. First, it is much easier to record the data when it is fresh and you don't have to reconstruct the trip from your notes. Second, it is hard to find time to sit down and reconstruct the trip at a later date. An example of a completed trip report is included as Exhibit 4.

Here are a few points on completing the summary.

Actual Time at stations (and in some instances at key check points) is recorded in the second column from the left. It may be done in seconds, but the arithmetic is easier if it is converted to tenths of a minute. Schedule time is the number of minutes from the departure at one station to the next station, as shown in the current timetable. This column should be filled out in advance of the trip.

Elapsed Time is the number of minutes from the departure at the last station until departure at the next station or arrival at the final station. At en-route stations where both an arrival time and a departure time are shown, such stations are generally shown as a separate entry.

Dwell Time is the number of minutes standing at the station shown, and for second or third spots it is the amount of time from the first stop until the last departure.

Delays are recorded directly from your Work Sheet from one station to the next.

Pure Running Time is elapsed time minus dwell time and delays. For example, on Exhibit 4, the elapsed time between Waldo and Ocala was 54.7 minutes. Pure Running Time was 54.7 less 4.7 minutes dwell and 12.2 minutes of delay or 37.8 minutes.

Recovery Time is the difference between Pure Running Time (PRT) plus Dwell Time and Schedule Time. This number may be negative or positive. Using the above example between Waldo and Ocala, the PRT was 37.8 minutes plus a dwell of 4.7 minutes for a total of 42.5 minutes. Under schedule time you note that 45 minutes is allowed; therefore, the recovery time is a positive 2.5 minutes. The recovery time station to station is recorded in the upper left portion of the recovery time column, while the cumulative recovery time is recorded in the lower right portion. Again, looking at the same example, there is 2.5 minutes recovery time between Waldo and Ocala and 7.6 minutes recovery time between Jacksonville and Ocala. As a second example, look at Deerfield Beach to Ft. Lauderdale. There is a negative 3.6 minutes recovery time between those stations, but there is a positive 37.4 minute recovery time between Jacksonville and Ft. Lauderdale.



As a check on your arithmetic, the bottom lines on your Summary Sheet (Trip Report) should total, PRT plus Dwell Time plus Recovery Time should equal Schedule Time.

# SUMMARY SHEET (Trip Report)

EXHIBIT 4

Date 2-5-96

## TRIP REPORT

Rider JLL

Train 91 Engs. 401-263

Consist 9 Cars

| SCHEDULE | ACTUAL             | STATION         | SCHED. TIME | ELAPSED TIME | DWELL | DELAYS                                                 | PURE-RUNNING TIME | RECOV. TIME  |
|----------|--------------------|-----------------|-------------|--------------|-------|--------------------------------------------------------|-------------------|--------------|
| 635 AM   | 8:17:50            | Jacksonville    |             |              |       |                                                        |                   |              |
| 734 AM   | 9:28:32<br>9:32:20 | Waldo           | 59          | 74.5         | 3.8   | 4.3 Inspn; 4.1 Sigs & S/s<br>7.7 Sigs                  | 50.1              | 5.1<br>5.1   |
| 819 AM   | 10:22.4<br>10:27.1 | Ocala           | 45          | 54.7         | 4.7   | 4.7 Slow order<br>7.5 Inspn.                           | 37.8              | 2.5<br>7.6   |
| 848 AM   | 10:53.8<br>10:54.1 | Wildwood        | 29          | 27.0         | 0.3   | none                                                   | 26.7              | 2.0<br>9.6   |
| 926 AM   | 11:33.2<br>11:33.6 | Dade City       | 38          | 39.5         | 0.4   | Slow order 2.0<br>0.9 Signal                           | 36.1              | 1.5<br>11.1  |
| 1016 AM  | 12:18.1<br>12:20.8 | Winter Haven    | 50          | 47.3         | 1.7   | 3.6 Signals                                            | 42.0              | 6.3<br>17.4  |
| 1057 AM  | 12:55.1<br>12:58.5 | Sebring         | 41          | 37.6         | 3.4   | none                                                   | 34.2              | 3.4<br>20.8  |
| 1132 AM  | 1:40.3<br>1:40.6   | Okeechobee      | 35          | 42.1         | 0.3   | 9.2 local freight                                      | 31.6              | 3.1<br>23.9  |
| 1235 PM  | 2:30.6<br>2:34.5   | West Palm Beach | 63          | 53.9         | 3.9   | none                                                   | 50.0              | 9.1<br>33.0  |
| 1256 PM  | 3:14.6<br>3:15.3   | Delray Beach    | 21          | 40.8         | 0.7   | WPA 9.6 Tri Rail<br>Lk Work 6.1 #98<br>Boynton Sil #92 | 19.0              | 1.3<br>34.3  |
| 115 PM   | 3:31.8<br>3:34.6   | Deerfield Beach | 19          | 19.3         | 2.8   | Yamato 7.0 Tri Rail                                    | 9.5               | 6.7<br>41.0  |
| 133 PM   | 3:58.0<br>4:01.0   | Ft. Lauderdale  | 18          | 26.4         | 3.0   | 4.8 Slow Order                                         | 18.6              | -3.6<br>37.4 |
|          |                    |                 |             |              |       |                                                        |                   |              |
|          |                    |                 | 418         | =            | 25.0  |                                                        | + 355.6           | + 37.4       |

## Delays

What constitutes a delay?

A broad definition is any condition which prevents the train from making normal speed between stations or to remain standing at a station in excess of the scheduled dwell time.

A delay begins when the engineer first sets the brake to slow down and continues until normal speed is resumed. This means that deceleration and acceleration are components of the delay -- not just standing time or time lost running at the slower speed. The territory from the beginning to the end of the delay is the Delay Zone.

Station dwell time delays are the amount of time that the train is in the station in excess of its scheduled dwell time. This would include time for second or even third spots. The dwell time would be from the first stop until the last departure, but the delay would be the elapsed time less the allotted dwell time. Although the practice appears to be disappearing, some crews still may report all standing time as a delay. This is not correct, delay is only the amount of time in excess of the scheduled dwell time.

Remember, dwell time for each station is built into the schedule. The actual amount of time the train is at a station should be recorded in the dwell time column of the Summary Sheet (Trip Report) even if it includes some delay.

Killing time is a delay. It comes in two forms. The first is operating slower than the authorized speed in order to kill time before arriving at some point too early. The second is the amount of time standing at a station once the work is completed waiting for the departure time. These must be recorded as delays.

The explanation of station delays should be based upon the function that caused the train to be late -- in other words, the last function or functions performed. If the passengers are loaded on time and there is a 3-minute delay to complete baggage and express work, the delay is baggage and express, not passenger loading. In like manner, if there is a 7-minute delay to water the diner, that is the delay, not mail and baggage.

En route delays are harder to quantify but should include all explanations as to why the train cannot operate at the maximum authorized speed. This would include slow orders, bulletin restrictions, work orders and all similar restrictions. Signals are also a significant cause of delay but are somewhat more complicated to identify.

When an Advance Approach or an Approach Medium signal is encountered, you need to capture the time at a finite point before the engineer sets the brake and the delay continues until a Clear signal is encountered and normal speed is resumed. Signal delays generally fall into two categories. The first is a signal failure where there is a malfunction of the system. This is always a signal delay. The second is where the signals are functioning as intended but are restrictive because there is a train ahead or

an opposing train is clearing. If the cause is known, these delays should be reported as a meet or following a train.

Following are some examples of signal occurrences.

1. Engineer says, "Dispatcher is asleep again," and slows for an Approach signal. He then keys in the dispatcher on the radio but before a conversation takes place, the signal mysteriously clears. This is a delay.
2. You ask the engineer, "Do you normally get a Restricting signal here?" He responds, "No, we normally get a Medium Clear." This is a delay, but the delay is the difference between what the Medium Clear running time would have been and the actual time caused by the Restricting signal. This is not necessarily the track speed.
3. You encounter an Approach Medium signal followed by 3 or 4 Approach signals, a Restricting signal, finally a Clear signal. This is a signal delay, but you do not have to quantify the delay at each signal, only beginning to endpoint for a total signal delay.
4. You receive an Approach Medium signal and you ask the engineer if he normally gets this indication. He responds, "Yes, we go to single track at Ajax." This is not a delay.

5. You receive a similar indication on a two main track rail line and the engineer says, "Yes, we have to crossover to be on the south side for the platform at Elyria." This also is not a delay.

6. A gray area is where two or more main track are in service and the dispatcher periodically crosses you over to go around traffic or to meet opposing traffic. This is a normal operating practice in multiple track territory with reverse signaling. Although it is a good practice to quantify this as a delay, the need to crossover must be considered in schedule construction. When two crossover moves can be attributed to a specific causal factor, such as operating around a freight train or a M of W gang, the justification for reporting it as a delay is much stronger.

What about an engine "not loading properly"?

An engine not loading properly effectively kills a schedule check. First, it is hard to quantify unless you know what the appropriate time should be. Second, if the unit is isolated, it destroys the power-to-weight ratio. A test with two units and 14 cars effectively becomes one unit and 16 cars if a unit is isolated. If this occurs, sit back and relax and watch the dwell times.

In addition to quantifying delays, what else am I looking for?

There are three basic areas you need to observe during the course of the riding program that are by-products or benefits gained by virtue of the fact that you are checking the schedule. The first is the quality of the existing schedule -- does it need to be restrung? Second is the quality of the train dispatching -- how well is it executed? The engineer will often give you valuable tips in this area. Third is the quality of the train handling. It is critical to the integrity of the test. Remember, you are not there to certify or test the engineer, but his handling of the train is critical to the integrity of the test. Operating above the speed limit is rare, below the speed limit is more common. Remember, operating below the speed limit is a delay. When this is observed you have two options -- either start recording the lost time as a delay<sup>2</sup> which is a continuing and difficult task, or, as an alternative, a firm request should be made to run at the speed limit; a second request is also appropriate if necessary. If this does not result in an improvement, then you categorize the engineer as a Type III engineer and make a note on the riding report accordingly. Engineers are professionals but they also vary somewhat in performance and fall into various general types. The following matrix may appear facetious but it is not. It ties back to the integrity of the schedule check as you will see later.

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<sup>2</sup>Technically, operating above the speed limit is a negative delay and would have to be quantified and factored into the PRT to maintain the integrity of the check.

## **Engineers Profile**

| <b><u>Profile</u></b> | <b><u>Handles Train</u></b>                                                                                                                                                                                                                                           | <b><u>Station Stops</u></b>                                                                                                        | <b><u>Attitudes</u></b>                                                                                                                                                                                         |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Engineer<br>Type I    | Maintains speed limit for miles. Brakes for speed restrictions, kicks off brake at 45, right on 40 mph at beginning of 40 mph restriction, maintains speed through restriction, notches out on throttle as rear car leaves restriction.                               | Comes in at a good speed; advises spot is second light pole past elevator. Is stopping when conductor says one car; stops on mark. | Takes great pride in work and is equally proud of length of service. Enjoys maintaining schedule.                                                                                                               |
| Engineer<br>Type II   | Runs within 1 or 2 mph of speed limit, brakes a little early for restrictions, is 1 or 2 mph under restrictions but compensates for same.                                                                                                                             | Comes into station some-what slower but is well under control when conductor says three cars. Stops on spot.                       | Explains has only been on job a short time. Enjoys work. Complains about train crew.                                                                                                                            |
| Engineer<br>Type III  | Runs 3 mph below speed limit, brakes early for restrictions, kicks brake off for 40 mph restriction at 40 and promptly slows to 35 mph but accelerates to 37 mph. Not sure where end of restriction is.                                                               | Comes into station slow, not sure where spot is, loses a little time at each station.                                              | It's an O.K. job. Does not like dispatchers, M of W personnel, signal maintainers, some train crews, and road foremen.                                                                                          |
| Engineer<br>Type IV   | Runs 3 mph below speed limit unless can get away with 5 under. Brakes early, kicks off brake at 40 for 40 mph restriction, at least 1/10 mile before restriction, promptly slows to 33 mph and jogs through restriction at 33, slow to respond at end of restriction. | Comes into station very slow, about 4 mph; nearly stalls or stalls as conductor calls three cars.                                  | Complains a lot. Should not have left ranch in Montana. Currently should be in yard service. Generally dislikes most everyone. No sense of urgency. All problems relate to lack of power and train dispatchers. |

Type I and Type II engineers will probably represent 90% or even 95% of the trips. The quality of these schedule checks will be very good. Type III engineers represent only a small percentage of the trips, but those trips need to be clearly identified as "soft" times so they do not distort the good trips. Some "soft" times include station stops where time can be lost coming into a station slow looking for a spot. On those rare occasions when a Type IV engineer is encountered, throw the riding report away as it has no value and is likely to badly distort the data obtained from the good trips. A conscientious engineer can be a valuable team member. Listen to their advice; they can be a real help.

### **Calculating the Impact of Delays**

Before we get into the calculation of delays, consider the "3600 Rule." This is an important element in calculating speeds or delays, as follows:

- 3600 divided by Seconds Per Mile equals Miles Per Hour.
- 3600 divided by Miles Per Hour equals Seconds Per Mile.

Example:      $\frac{3600}{\text{mph}} = \text{Seconds Per Mile}$  (or)  $\frac{3600}{60 \text{ mph}} = 60 \text{ Seconds Per Mile}$

$\frac{3600}{\text{spm}} = \text{Miles Per Hour}$      (or)  $\frac{3600}{45 \text{ spm}} = 80 \text{ Miles Per Hour}$

This should be memorized and will become invaluable in calculating delays.

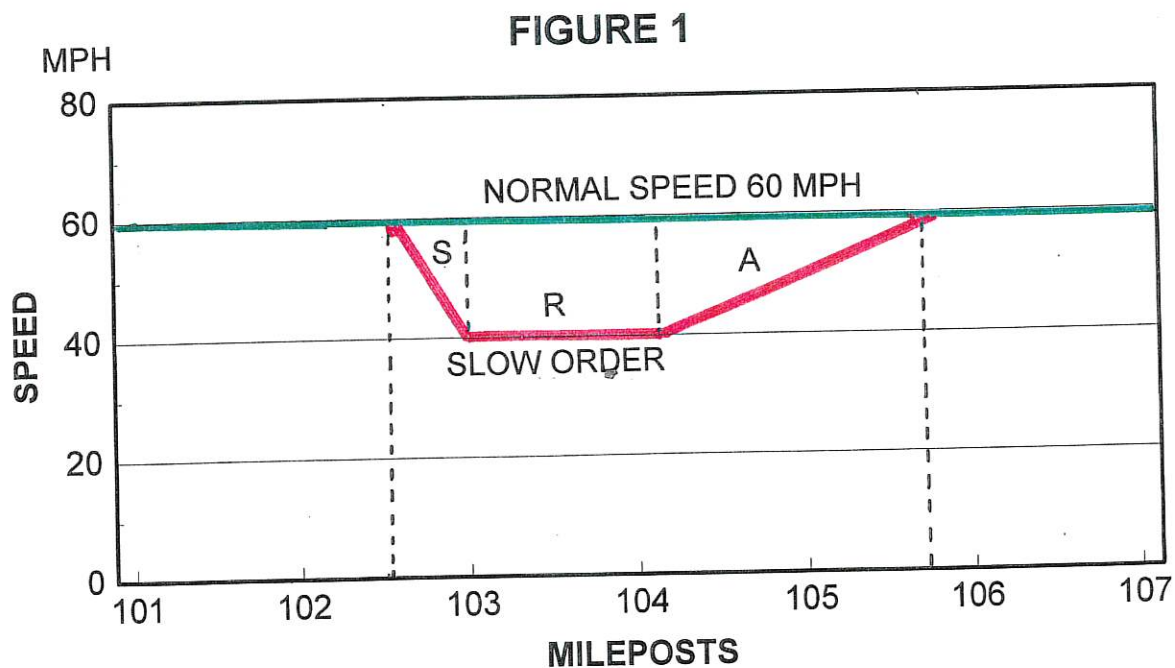
The amount of delay is the difference between theoretical running time, if the train was not delayed, and actual running time.



The delay starts when the engineer first sets the brake to reduce speed and continues until the maximum speed is restored.

In calculating authorized speeds do not overlook the length of the train, generally 0.1 to 0.3 miles, which must be added to each restriction before the train can accelerate. Some road crossing restrictions identified as "head end only" apply only until the crossing is occupied.

Consider the following basic example where a 40 mph slow order exists on trackage that is normally 60 mph: "Do not exceed 40 mph between MP 103 and MP 104."



The delay consists of three components:

1. Deceleration S
2. Restriction R
3. Acceleration A

The total delay (D) is equal to  $S + R + A$ .

In the above Figure, S is the amount of time lost to slow down, R is the time lost due to the restriction and train length, and A is the time lost due to accelerating.

If the train passes MP 102 at 10:40:00, at the maximum speed of 60 mph, it would pass MP 106 at 10:44:00

Running Time: 4.0 minutes

|                     |        |    |          |        |
|---------------------|--------|----|----------|--------|
| Actual performance: | MP 102 | at | 10:40:00 | 60 mph |
|                     | MP 103 | at | 10:41:44 | 40 mph |
|                     | MP 104 | at | 10:43:14 | 40 mph |
|                     | MP 105 | at | 10:44:33 | 54 mph |
|                     | MP 106 | at | 10:45:35 | 60 mph |

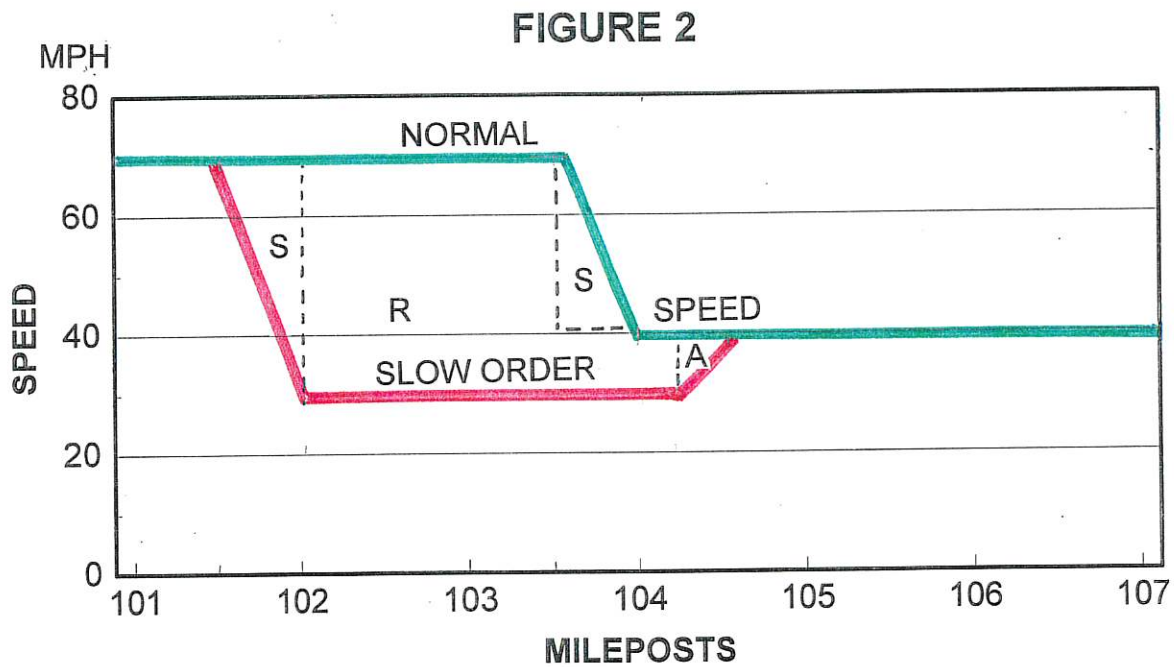
Running Time: 5.6 minutes

Actual Delay: 1.6 minutes

In measuring the delay you do not need the intermediate mile posts, only MP 102 and MP 106. What if you miss MP 106 and catch MP 107? Since the speed limit between MP 106 and MP 107 is 60 mph and the train is running at 60 mph, the amount of delay will not change if it is calculated to MP 107.

It should be noted that a delay cannot be accurately measured from the point where the engineer applies the brake without a finite point where the time can be recorded. The same is true when the maximum speed has been resumed.

In Figure 2 we explore calculations where the maximum authorized speed change within the slow order zone. The restriction is "Do not exceed 30 mph between MP102 and MP104."



In Figure 2 the normal speed changes within the delay zone. The train does not decelerate between MP 103 and MP 104 as it normally would but accelerates after it has left the restriction. This requires separate calculations to determine the delay.

| Normal Speed                       |          |         | Slow Order Speed |          |        |
|------------------------------------|----------|---------|------------------|----------|--------|
| MP 101                             | 11:10:00 | 70 mph  | MP 101           | 11:10:00 | 70 mph |
|                                    |          | Seconds |                  |          |        |
| MP 101.0-103.5                     | 70 mph   | 129     |                  |          |        |
| MP 103.5-104.0                     | 70 to 40 | 33      |                  |          |        |
| MP 104.0-107.0                     | 40 mph   | 270     | MP 107           | 11:20:33 | 40 mph |
| Elapsed Time:                      |          | 432"    | Elapsed Time:    |          | 633"   |
| or                                 |          | 7'12"   | or               |          | 10'33" |
| The delay is 3'21" or 3.3 minutes. |          |         |                  |          |        |

Now the question is, how do you calculate the delay?

There are two basic methodologies, remember  $D = S + R + A$ . Also remember that the amount of delay is the difference between normal speed and actual speed. While the above example is in its simplest form with one normal speed change within the delay zone, it is possible to have five or six normal speed changes and two or three slow order speeds in the same zone which thoroughly complicates the procedure.

In the above example there are two deceleration and one acceleration zones. Excluding these areas, the common area (R) for the restriction is only 1.5 miles in length. This is easy to calculate since it is the differential (or delta) between the two speeds. The difficult calculations are deceleration and acceleration.

The first methodology is using the Acceleration/Deceleration Tables which are included in Appendix I. This is analogous to using the tax tables to determine your income tax. The tables were developed some time ago from actual field observations and show the amount of delay resulting from decelerating and accelerating based upon F-40 locomotives and three different train consists. The tables are a reasonable guide for the new evaluators. Remember, however, the terrain over which the train is being operated may have a material effect upon acceleration characteristics and some impact upon braking distances. The tables are based upon level track and do not compensate for grades.

Over a period of time you may want to develop your own tables based upon different power-to-weight ratios from your own experience, but don't worry about that until you have significant experience.

The second methodology is Speed Averaging. Note the example above in Figure 2 which shows two tables -- normal speed and slow order speed. The normal speed table used speed averaging. Under this methodology deceleration and acceleration calculations are made by averaging the beginning and the final speed and then multiplying the average by the distance in order to determine the time required.

Example: If we assume the deceleration rate is 10 mph per 0.1 mile plus 0.1 mile for actuation, and the speed is to be reduced from 70 mph to 30 mph, it will

require one-half mile. The beginning speed is 70 mph; the final speed is 30 mph; and the average speed is 50 mph or 72 seconds per mile times 0.5 mile or 36 seconds. At 70 mph this same half mile would consume 25.7 or 26 seconds, so the time lost is actually 10 seconds.

Acceleration requires longer distances and therefore more time is lost. If acceleration from 30 mph to 70 mph requires 1.5 miles, the average speed is again 50 mph but the distance is 3 times longer than deceleration. If you again multiply 72 seconds by 1.5 miles, the time to accelerate is 108 seconds. At 70 mph this same 1.5 miles would consume 77 seconds so the time lost is 31 seconds.

The above examples total 41 seconds lost; however, if you did the same calculation using the 2 + 9 speed table, the result would be 43 seconds lost. The table for a three-car train shows a loss of 27 seconds.

When you have to make comparative calculations, make a table such as the one shown above. Remember, deceleration must be completed before the restriction is entered, and the length of the train must be factored into the end of the restriction before acceleration can begin.

How accurate are these methodologies? Over years these methodologies have been compared, including Train Performance Calculator (TPC) computer runs. Comparisons have shown a variance in 100 miles of less than 30 seconds; or a field

calculation and a TPC run comparison to the second over a 40-mile segment. If the calculations are carefully done, the results are unbelievably close.

## **Conclusion**

The calculation of delays and breaking a schedule into its basic components is not an exact science; however, it can be done with great accuracy. Armed with the knowledge contained in this paper, you should be able to properly evaluate a schedule. However, one critical element is experience. As you gain experience you should improve your proficiency and the task becomes easier. For those persons who are new riders, it is important to make a training ride with an experienced rider as soon as possible to put into practice what you have learned in the classroom. This should be followed with a second trip on your own. If the end results of the early rides are not good, throw them in the wastebasket just as you would for a trip with a Type IV engineer, so they do not distort the findings of other trips when it comes to schedule stringing. Finally, always remember that safety is of first importance, not only your personal safety but also the safety of other employees and the passengers. The operation of the train must be in conformity with the rules in order to maintain a safe operation. In closing, we would offer this advice: "Have a safe trip."



**APPENDIX I**  
**DECELERATION AND ACCELERATION**  
**DELAY TABLES**

Note: Distance (miles) shown in the following tables is distance required to accelerate, not to decelerate.

TABLES SHOWING TIME LOST IN  
ACCELERATION & DECELERATION  
& DISTANCE TRAVELLED IN ACCELERATION

| Speed Increase |      |     | Distance (Miles) | Time (Sec.): |        |
|----------------|------|-----|------------------|--------------|--------|
| Increase       |      |     | (Miles)          | Accel.       | Decel. |
| 0-20 =         | .075 | 6   | 3                |              |        |
| 25 =           | .15  | 10  | 5                |              |        |
| 30 =           | .23  | 13  | 7                |              |        |
| 35 =           | .3   | 16  | 8                |              |        |
| 40 =           | .4   | 18  | 9                |              |        |
| 45 =           | .5   | 20  | 10               |              |        |
| 50 =           | .7   | 25  | 12               |              |        |
| 55 =           | .9   | 29  | 14               |              |        |
| 60 =           | 1.1  | 33  | 16               |              |        |
| 65 =           | 1.4  | 38  | 19               |              |        |
| 70 =           | 1.7  | 43  | 21               |              |        |
| 75 =           | 2.1  | 49  | 24               |              |        |
| 80 =           | 2.5  | 55  | 27               |              |        |
| 10-20 =        | 0.5  | 2   | 1                |              |        |
| 25 =           | .1   | 4   | 1                |              |        |
| 30 =           | .18  | 6   | 3                |              |        |
| 35 =           | .25  | 8   | 4                |              |        |
| 40 =           | .35  | 10  | 5                |              |        |
| 45 =           | .50  | 14  | 7                |              |        |
| 50 =           | .65  | 17  | 8                |              |        |
| 55 =           | .85  | 21  | 11               |              |        |
| 60 =           | 1.05 | 24  | 12               |              |        |
| 65 =           | 1.35 | 29  | 15               |              |        |
| 70 =           | 1.65 | 34  | 17               |              |        |
| 75 =           | 2.15 | 41  | 22               |              |        |
| 80 =           | 2.45 | 45  | 23               |              |        |
| 20-25 =        | .05  | 1   | 0.5              |              |        |
| 30 =           | .1   | 2   | 1                |              |        |
| 35 =           | .2   | 3.5 | 2                |              |        |
| 40 =           | .3   | 5   | 3                |              |        |
| 45 =           | .4   | 7   | 4                |              |        |
| 50 =           | .6   | 10  | 5                |              |        |
| 55 =           | .8   | 14  | 7                |              |        |
| 60 =           | 1.0  | 17  | 8                |              |        |
| 65 =           | 1.3  | 21  | 11               |              |        |
| 70 =           | 1.6  | 26  | 13               |              |        |
| 75 =           | 2.0  | 31  | 16               |              |        |
| 80 =           | 2.4  | 36  | 18               |              |        |

# ACCELERATION & DECELERATION DELAYS ONE F-40 LOCOMOTIVE & EIGHT PASSENGER CARS (AMFLEET)

| Speed |   | Seconds for:<br>Accel. Decel. |    | Speed |   | Seconds for:<br>Accel. Decel. |    | Speed |   | Seconds for:<br>Accel. Decel. |   |
|-------|---|-------------------------------|----|-------|---|-------------------------------|----|-------|---|-------------------------------|---|
| 0-10  | = | 6                             | 3  | 20-25 | = | 2                             | 1  | 35-40 | = | 2                             | 1 |
| 15    | = | 9                             | 5  | 30    | = | 4                             | 2  | 45    | = | 4                             | 2 |
| 20    | = | 12                            | 6  | 35    | = | 7                             | 4  | 50    | = | 7                             | 4 |
| 25    | = | 18                            | 9  | 40    | = | 9                             | 5  | 55    | = | 11                            | 6 |
| 30    | = | 24                            | 12 | 45    | = | 13                            | 7  | 60    | = | 16                            | 8 |
| 35    | = | 27                            | 14 | 50    | = | 19                            | 10 |       |   |                               |   |
| 40    | = | 32                            | 16 | 55    | = | 25                            | 13 | 40-45 | = | 1                             | 1 |
| 45    | = | 37                            | 19 | 60    | = | 33                            | 17 | 50    | = | 4                             | 2 |
| 50    | = | 43                            | 22 |       |   |                               |    | 55    | = | 8                             | 4 |
| 55    | = | 52                            | 26 |       |   |                               |    | 60    | = | 12                            | 6 |
| 60    | = | 62                            | 31 |       |   |                               |    |       |   |                               |   |
| 10-15 | = | 3                             | 2  | 25-30 | = | 2                             | 1  | 45-50 | = | 1                             | 1 |
| 20    | = | 5                             | 3  | 35    | = | 3                             | 2  | 55    | = | 4                             | 2 |
| 25    | = | 9                             | 5  | 40    | = | 5                             | 3  | 60    | = | 7                             | 4 |
| 30    | = | 13                            | 7  | 45    | = | 9                             | 5  |       |   |                               |   |
| 35    | = | 17                            | 9  | 50    | = | 13                            | 7  |       |   |                               |   |
| 40    | = | 20                            | 10 | 55    | = | 20                            | 10 | 50-55 | = | 1                             | 1 |
| 45    | = | 25                            | 13 | 60    | = | 27                            | 14 | 60    | = | 3                             | 2 |
| 50    | = | 31                            | 16 | 30-35 | = | 2                             | 1  |       |   |                               |   |
| 55    | = | 40                            | 20 | 40    | = | 5                             | 3  |       |   |                               |   |
| 60    | = | 48                            | 24 | 45    | = | 9                             | 5  |       |   |                               |   |
| 15-20 | = | 2                             | 1  | 50    | = | 13                            | 7  |       |   |                               |   |
| 25    | = | 5                             | 3  | 55    | = | 16                            | 8  |       |   |                               |   |
| 30    | = | 8                             | 4  | 60    | = | 23                            | 12 |       |   |                               |   |
| 35    | = | 11                            | 6  |       |   |                               |    |       |   |                               |   |
| 40    | = | 15                            | 8  |       |   |                               |    |       |   |                               |   |
| 45    | = | 19                            | 10 |       |   |                               |    |       |   |                               |   |
| 50    | = | 25                            | 13 |       |   |                               |    |       |   |                               |   |
| 55    | = | 33                            | 17 |       |   |                               |    |       |   |                               |   |
| 60    | = | 41                            | 21 |       |   |                               |    |       |   |                               |   |

ACCELERATION & DECELERATION DELAYS  
TWO F-40's & NINE SUPERLINER CARS  
(Page 1 of 2)

| Speed |  |  | Distance (Miles) |  |  | Time (Sec.): |  |  | Distance (Miles) |  |  | Time (Sec.): |  |  |
|-------|--|--|------------------|--|--|--------------|--|--|------------------|--|--|--------------|--|--|
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
|       |  |  |                  |  |  |              |  |  |                  |  |  |              |  |  |
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ACCELERATION & DECELERATION DELAYS  
TWO F-40's & NINE SUPERLINER CARS  
(Page 2 of 2)

| Speed     | Distance<br>(Miles) | Time (Sec.): |        |
|-----------|---------------------|--------------|--------|
|           |                     | Accel.       | Decel. |
| 20 - 65 = | 1.9                 | 32"          | 16"    |
| 70 =      | 2.4                 | 39"          | 19"    |
| 75 =      | 3.0                 | 46           | 23"    |
| 80 =      | 3.7                 | 55"          | 27"    |
| 85 =      | 4.5                 | 65"          | 32"    |
| 90 =      | 5.4                 | 74"          | 37"    |

| Speed   | Distance<br>(Miles) | Time (Sec.): |        |
|---------|---------------------|--------------|--------|
|         |                     | Accel.       | Decel. |
| 40-45 = | .3                  | 1"           | 0.5"   |
| 50 =    | .5                  | 3"           | 1"     |
| 55 =    | .8                  | 6"           | 3"     |
| 60 =    | 1.2                 | 9"           | 4"     |
| 65 =    | 1.6                 | 13"          | 6"     |
| 70 =    | 2.1                 | 18"          | 9"     |
| 75 =    | 2.7                 | 23"          | 11"    |
| 80 =    | 3.4                 | 30"          | 15"    |
| 85 =    | 4.2                 | 35"          | 17"    |
| 90 =    | 5.1                 | 46 "         | 23"    |

| Speed   | Distance<br>(Miles) | Time (Sec.): |        |
|---------|---------------------|--------------|--------|
|         |                     | Accel.       | Decel. |
| 70-75 = | .6                  | 1"           | 0.5"   |
| 80 =    | 1.3                 | 2"           | 1"     |
| 85 =    | 2.1                 | 5"           | 2"     |
| 90 =    | 3.0                 | 9"           | 4"     |
| 75-80 = | .7                  | 1"           | 0.5"   |
| 85 =    | 1.5                 | 2"           | 1"     |
| 90 =    | 2.4                 | 6"           | 3"     |